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Additive Manufacturing of Carbides using Renewable resources

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Introduction

WHAT? A novel additive manufacturing process of carbides using a biopolymer-metal oxide composite as the precursor material.

WHY?
- Renewable biopolymers replace petroleum-based ones as carbon source;
- The temperature needed for carbide formation is drastically reduced due the colloidal proximity of the reactants.
- Additive manufacturing of a precursor gel composite could enable complex shapes, especially those currently challenging for powder pressing or machining of bulk carbides.

Materials

Material	What it is	General Application	Role in our work
Iota-carrageenan	Polysaccharide extracted from red edible seaweeds	Food industry	Carrier
Cellulose	Polysaccharide, linear long chain of D-glucose	Paper and Paperboard	Bio-filler
Chitin	Long-chain polymer of a *N*-acetylglucosamine, a derivative of glucose.	Exoskeleton of shrimp, crab and lobsters	Bio-filler
Silica nanoparticle	5-10 nm amorphous nanoparticles	-	Metal oxide nanoparticle (MONP)

Experimental Process

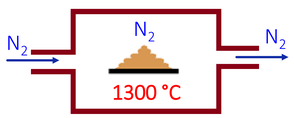
MONP DISPERSION (5 WT% IN DI WATER)
SONICATION
Power ~ 35W
Time ~ 15 min

BIOPOLYMER MIX
Carrier:Bio-filler
1:4 wt%

COMPOSITE GEL

MANUAL EXTRUSION

HEAT TREATMENT UNDER N2
- Heating Ramp: 5 °C/min
- 75 min dwell at 1300 °C

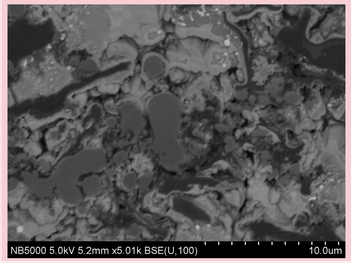
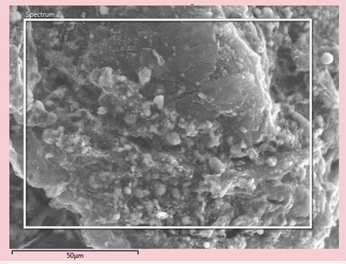
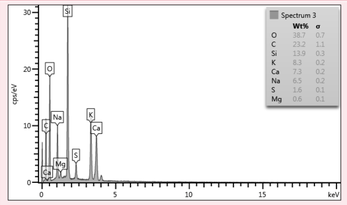
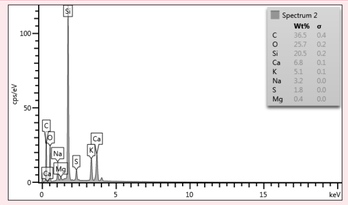
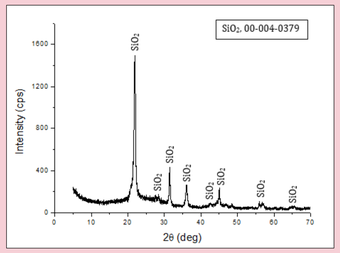
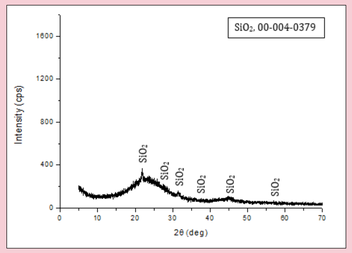


A) Iota-carrageenan/cellulose

B) Iota-carrageenan/chitin

CARBONACEOUS MATERIAL

Results

Sample	A) Iota-carrageenan/cellulose	B) Iota-carrageenan/chitin
SEM		
EDX		
XRD		
BET	399.6723 m^2/g	232.0953 m^2/g

Conclusion

- Amorphous, Porous, carbonaceous material with many impurities
- Water is the expected source of contaminants. Switch to high purity water.
- Explore higher carbonization temperatures and/or more reductive environments.
- Precursor shape is maintained during carbonization. Shrinkage happens.
- High surface area.

Towards Additive Manufacturing

Different perspective	Parameters of Interest	Reason for interest	Plan to solve
Additive manufacturing	Rheology of gels	Scale of manufacturing, Structural, Extrusion rate, Layer bonding? Overhangs?	Different weight ratio of gel components
	x-y-z motion	3D manufacturing	3-axis gantry motion system
Heat treatment	Temperature	Carbothermal reaction	T>1300 °C
	Dwell time	Complete reaction	Longer dwell time
	Environment	To avoid oxidation	Vacuum
Precursor Composition	Amount of MONP	Avoid localized reaction	Increase % MONP
	Water source	To avoid contamination	Ultra-pure water
	MONP dispersion	Single particle dispersion	Use surfactant

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THANK YOU!

Visit: www.multiscalemanufacturing.net